MATERNAL AND CHILD HEALTH SERVICES ECONOMICS IN MCH

VOLUME 2

A Review of Descriptive Cost Studies and Economic Evaluations of Maternal and Child Health Interventions

Division of Science, Education, and Analysis
Maternal and Child Health Bureau, HRSA, PHS, DHHS
Parklawn Building
5600 Fishers Lane
Rockville, Maryland 20857

U.S. Department of Health & Human Services
Public Health Service
HRSA
Health Resources & Services Administration
Maternal & Child Health Bureau

MCHB
Maternal and Child Health Bureau

Abstract

The second in the MCHB's series on economics in maternal and child health, this document provides a review and synthesis of selected economic studies of maternal and child health services. The review focuses on three types of programs: those intended to encourage early use of prenatal care, those aimed at reducing rates of smoking during pregnancy, and those intended to encourage childhood immunization. For each of these sets of services, the report first describes the health problem. It then describes the studies reviewed, assesses the methodologies used, summarizes the findings of the studies, and discusses the gaps in the literature and the directions for further analyses in the area. A brief summary of the status of cost analyses in the maternal and child health field concludes the report.

ECONOMICS IN MCH

Volume 2:

A Review of Descriptive Cost Studies and Economic Evaluations of Maternal and Child Health Interventions

Prepared by:

Norma I. Gavin, Ph.D. and Karen S. Lissy
Research Triangle Institute
Research Triangle Park, NC

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I. Introduction

This manuscript is the second in a series developed by the Maternal and Child Health Bureau's Division of Science, Education and Analysis to help maternal and child health professionals understand and use economic analysis. The first monograph, *An Introduction to Economic Analysis for MCH Practitioners* (Schwalberg et al., 1998), provided an introduction to the terminology, methods, and uses of economic analysis. This monograph provides a review of economic studies in women and children's health.

The purpose of the review is to illustrate the spectrum of studies and methodologies than can be used to inform decisions faced by MCH policy makers. An exhaustive search of the literature for examples of all the points discussed in Volume 1 was not feasible within the constraints of the current study. However, the results of our search does provide an assessment of the breadth and depth of the published literature on a few selected MCH topics.

To emphasize policy-relevant studies, we chose five sets of *Healthy People 2000* goals on which to concentrate our literature search. All are focused on primary prevention strategies, and they include strategies aimed at both women in their child-bearing years and different age groups of children. These goals are:

- Reduce the infant mortality rate to no more than 7 per 1,000 live births (objective 14.1), and increase to at least 90 percent the proportion of all pregnant women who receive prenatal care in the first trimester of pregnancy (objective 14.11).
- Reduce cigarette smoking to a prevalence of no more than 10 percent among pregnant women (objective 3.42); increase smoking cessation during pregnancy so that at least 60 percent of women who are cigarette smokers at the time they become pregnant quit smoking early in pregnancy and maintain abstinence for the remainder of their pregnancy (objective 3.7); and increase smoking cessation during pregnancy so that at least 45 percent of women with less than a high school education who are cigarette smokers at the time they become pregnant quit smoking early in pregnancy and maintain abstinence for the remainder of their pregnancy (objective 3.7a).
- Reduce the proportion of adolescents who have engaged in sexual intercourse to no more than 15 percent by age 15 and no more than 40 percent by age 17 (objective 5.4); and increase to at least 40 percent the proportion of ever sexually

active adolescents aged 17 and younger who have not had sexual intercourse during the previous three months (objective 5.5).

- Increase immunization levels for the basic immunization series among children under age two to at least 90 percent and among children in licensed child care facilities and kindergarten through post-secondary education institutions to at least 95 percent (objective 20.11); and expand immunization laws for schools, preschools, and day care settings to all states for all antigens (objective 20.13).
- Reduce the initiation of cigarette smoking by children and youth so that no more than 15 percent have become regular cigarette smokers by age 20 (objective 3.5).

We searched for descriptive cost studies and economic evaluations of strategies designed to meet these objectives. We looked only for studies in the published literature in which costs or cost-effectiveness were the main theme of the study, rather than a supplemental or side study. We found no relevant economic analyses of smoking cessation aimed at adolescents or abstinence education programs for youth. Furthermore, we found only two studies and a description of a third planned study on strategies to increase childhood immunizations. However, for the objectives on early initiation of prenatal care and smoking cessation during pregnancy, a significant number of studies were found (12 and 11, respectively).

We reviewed and assessed the cost studies for the three objectives for which we found some studies. Summaries of the studies are presented in Appendix A. The methodology used in our literature search are presented in Appendix B. Chapters II to IV present the reviews of cost studies for early initiation of prenatal care, smoking cessation during pregnancy, and methods to increase immunization rates, respectively. In each chapter, we first describe the health problem. We then describe the studies found, assess the methodologies used, summarize the findings of the studies, and discuss the gaps in the literature and the direction for further analyses in the area. A brief summary of the status of cost analyses in the maternal and child health field concludes the report.

II. Early Initiation of Prenatal Care

The infant mortality rate, defined as the number of infants who die before their first birthday per 1,000 live births, was 7.5 deaths per 1,000 births in the United States in 1995 (Federal Interagency Forum on Child and Family Statistics, 1997). This rate was slightly below the 1994 rate of 8 per 1,000 and substantially below the 1980 rate of 12.6 per 1,000, but it remained higher than the rate in many other industrialized nations. The Surgeon General set a goal of no more than 7 infant deaths per 1,000 live births by the Year 2000. To help meet this goal, a *Healthy People 2000* target was set—that 90 percent of all pregnant women would initiate prenatal care in the first trimester of pregnancy.

Early prenatal care is considered crucial for reducing infant mortality as it allows for early detection and treatment of existing medical and obstetric conditions and provides an opportunity for encouraging healthy behavior and educating women early in their pregnancies about proper nutrition, adequate weight gain, dangers of smoking, alcohol and drugs, and other factors that may affect pregnancy outcomes (Lewis et al., 1996). Early and enhanced prenatal care has been the goal of several national programs and policies, including the expansion of Medicaid coverage to all pregnant women in families with incomes below 185 percent of the federal poverty level (FPL).

Studies of the cost-effectiveness of prenatal care in reducing poor birth outcomes and the resulting postnatal care expenditures were instrumental in shaping the government debate that led to these policies. Disappointing results of the expansion of Medicaid coverage has led to a reexamination of the costs and effectiveness of prenatal care (Huntington and Connell, 1994; Fiscella, 1995) and how prenatal care programs and policies for high-risk pregnancies are designed (Misra and Guyer, 1998). The cost-effectiveness of prenatal care for women at highest risk of poor birth outcomes (e.g., substance abusers) remains unproven. Considerable evidence links inadequate prenatal care to poor birth outcomes for these populations, but this evidence remains associative; the data demonstrate that prenatal care is a condition for good birth outcomes but are not sufficient to prove causality (LaGuardia, 1992; Fiscella, 1995).

Some evidence of a positive impact of the government efforts to increase early prenatal care has begun to emerge. Nevertheless, early initiation of prenatal care remains well below the 90 percent *Healthy People 2000* target. Prenatal care use, as measured by the trimester in which care began, was unchanged in the 1980s and only began to increase slightly in the early 1990s (Lewis et al., 1996). By 1995, 81.6 percent of pregnant women in the United States began prenatal care in the first trimester (Kogan et al., 1998). Mothers with the lowest likelihood of initiating early prenatal care were those with low educational attainment and presumptively low incomes, and African American, Puerto Rican and Native American mothers (Lewis et al., 1996).

In contrast to the small changes in the early initiation of prenatal care, a steady rise throughout the 1980s and 1990s was evident in the percentage of women with intensive prenatal care—that is, women who had at least 10 percent more prenatal care visits than were recommended by the American College of Obstetricians and Gynecologists for the gestational age of their newborns. This percentage grew from 18.4 percent in 1981 to 28.8 percent in 1995 (Kogan et al., 1998). However, at least two groups of women who are socially at high risk for poor pregnancy outcomes—African American and low-income women—did not share in the increased use of prenatal care at the intensive levels (Misra and Guyer, 1998).

In addition, despite the increases in prenatal care use, the rates of low birthweight (LBW) births (< 2,500 grams) worsened in the United States during this time. The LBW rate was 7.3 percent in 1995, up from 6.7 percent in 1984 (Ventura et al., 1998). LBW is a major predictor of infant mortality and the most common measure used to evaluate prenatal care because it is easily quantifiable, readily available on birth certificates, and requires smaller sample sizes to detect effect differences compared to mortality measures (Fiscella, 1995).

The worsening LBW rates are at least partly a result of reporting anomalies. Changes in the distribution of LBW and very low birthweight (VLBW) births and deaths (< 1,500 grams) have obscured improvements in infant mortality overall (Phelan et al., 1998). A recent study of linked live birth, infant death and fetal death records in Alabama found that over the past 20 years, neonatal mortality (deaths from birth to 28 days of age) declined 60 percent for infants weighing 500 to 999 grams and 90 percent for those weighing 1,000 to 1,499 grams. At the same time,

there was a 2.5-fold increase in the reporting of VLBW births. As the age of viability moved downward and efforts to save VLBW infants increased, more total births were recorded as live births rather than as spontaneous abortions or stillbirths (Phelan et al., 1998). This has caused an upward bias in the reported rates of neonatal and infant mortality.

Furthermore, merely increasing prenatal care use may have little impact if the care offered does not address the most salient risk factors for poor pregnancy outcomes and if women most at risk for poor pregnancy outcomes are not targeted. We also must look at the characteristics of the pregnancies and the content of care used to address those characteristics (Misra and Guyer, 1998).

A. Types of Cost Studies Reviewed

We searched MEDLINE for studies of the cost and cost-effectiveness of prenatal care. Because some seminal studies were conducted in the late 1980s, we extended our search and review back to 1985. The studies identified were of three types:

- Descriptive cost studies. Several types of cost-description studies were identified, including those analyzing the costs of prenatal care and neonatal care. We found two studies that described, respectively, the costs of poor access to prenatal care (Nesbitt et al., 1990) and poor birth outcomes in an employer-based health insurance plan (Chollet et al., 1996). Another study provided baseline estimates by source of payment of the costs and payments for maternal and infant care in the United States in 1989, the year preceding most of the recent Medicaid eligibility expansions (Long et al., 1994). Two other descriptive cost studies compared the direct medical costs of pregnancy outcomes between women who had some prenatal care and women who had no prenatal care (Henderson, 1994) and between women who had an adequate number of prenatal care visits for the gestational age of their newborn and women who had inadequate or no prenatal care (Wilson et al., 1992).

- Cost-benefit analyses. We found six studies that compared the costs of prenatal care to the increased costs of postnatal care in cost-benefit analyses of prenatal care. These studies variously investigated what the net savings would be if all high-risk pregnant women on public assistance had begun prenatal care in the first trimester (IOM, 1985); if all pregnant women delivering at an urban medical center with no prenatal care had had at least some prenatal care (Morales et al., 1985); if all pregnant women with no care had participated in a Comprehensive Perinatal Program (Moore et al., 1986); if Medicaid coverage was expanded to all pregnant

women living in families with incomes under the FPL (OTA, 1988); and if pregnant women who had received no or inadequate prenatal care visits had begun care in their first trimester and had received at least nine prenatal care visits (Gorsky and Colby, 1989; Schramm, 1992).

- Cost-effectiveness analyses. We found one cost-effectiveness study. Joyce et al. (1988) compared the cost-effectiveness of prenatal care in reducing infant mortality with the cost-effectiveness of various other strategies, including neonatal intensive care units (NICUs), abortion, family planning clinics, community health centers, maternal infant care projects, and WIC.

Below we review these cost studies of the early initiation of prenatal care. We first review the methodologies used in these studies and then summarize the studies' findings.

B. Review of Methodologies

The major dimensions of the 12 cost studies of prenatal care use are shown in Table A-1. Except for the OTA (1988) and Joyce et al. (1988) studies, they all took the perspective of the health care payer. Thus, they considered only direct medical care costs. For most studies, the analytic horizon was measured from the first prenatal care visit at least through discharge from the delivery hospital stay. Three studies limited the analytic horizon to the delivery stay (Nesbitt et al., 1990; Wilson et al., 1992; Henderson, 1994). Four others extended the horizon through to the child's first year of life (Chollet et al., 1996; Long et al., 1994; Gorsky and Colby, 1989; IOM, 1985), another extended the horizon to 60 days post delivery (Schramm, 1992), and one included long-term morbidity costs through to the child's 35th birthday (OTA, 1988). In the Joyce et al. (1988) cost-effectiveness analysis, the analytic horizon for the program costs varied by the time frame during which the different program/services are provided, and effectiveness was measured variously at birth (LBW) and within the first month following birth (neonatal mortality).

1. Types of Costs

As mentioned above, most studies included only direct medical costs. All of the cost descriptions and cost benefit analyses included at least the total or incremental hospital costs for the newborn during the initial (birth) stay. Only four studies also included delivery-related costs for the mother (Chollet et al., 1996; Long et al., 1994; Moore et al., 1986; Schramm, 1992). The reason for this

omission is that most of these studies are measuring benefits of prenatal care narrowly as the averted costs of LBW births rather than more broadly as averted costs from the spectrum of poor maternal and infant outcomes. The maternal costs for delivering a normal birthweight (NBW) infant versus a LBW infant are assumed to be equal and, therefore, to drop out of the equation. However, the costs associated with poor maternal outcomes, such as preeclampsia, placenta previa and abruptio placentae, can also be substantial (Adams and Melvin, forthcoming). The incidence and severity of these conditions, and hence the associated costs, may be reduced with early and adequate prenatal care. Chollet and colleagues found that maternal costs for prenatal, delivery and postnatal care averaged 27 percent higher (or $2,135 in 1989 dollars) for preterm and other infants with problems compared to NBW full-term infants (Chollet et al., 1996).

Among the nine studies that included the costs of prenatal care, most were restricted to outpatient care; only two considered pregnancy-related inpatient costs (Long et al., 1994; Chollet et al., 1996). None of the cost-benefit studies and only two of the cost descriptions included costs of postnatal care for the mothers (Long et al., 1994; Chollet et al., 1996). These two studies and four additional studies included costs for infants after discharge from their initial hospitalization. However, for one of these, the costs were restricted to inpatient costs during the first year and to the present discounted costs of early intervention, special education, and institutional or foster care for a fraction of LBW infants through their 35th birthday (OTA, 1988).

Finally, none of the studies considered the cost of outreach and support services, such as transportation and child care, that would be required to attain desired prenatal care use rates. Low-income women, relatively low users of prenatal care, must overcome more than just the financial barriers to care. These other barriers include the inadequate number of providers willing to serve low income women, the lack of transportation and child care, inconvenient hours of operation and inaccessible locations of care, and a lack of understanding of the importance of prenatal care. Interventions designed to alleviate these problems can be expensive (Huntington, and Connell, 1994).

2. Valuation of Costs

The breadth of cost types included in the different studies was directly related to the methods for valuing costs. The studies reviewed either presented the actual charges or payments for the population under study or gave synthetic estimates developed using "gross-costing" techniques.[1] Three main data sources were used to value the medical services included in the cost studies: (1) charge and payment data on claims data records; (2) charges from hospital and medical office billing records; and (3) the literature.

The broadest set of medical costs was found in the studies that used claims databases to estimate costs for an actual population group (Schramm, 1992; Long et al., 1994; Chollet et al., 1996). Claims databases include billed services from a wider range of providers than other sources. All covered service types can be included in cost estimates by selecting records based on diagnostic codes and/or service dates. By contrast, use of records from particular hospitals, clinics or physicians' offices is restricted to the costs of services rendered by those providers. Finally, the use of estimates of the incidence and average values of resources from the literature requires that the analyst specify all relevant resources ahead of time. This method usually leads to a smaller number of service types than the use of claims data or medical records.

A major problem with using synthetic estimates in which average costs are estimated on a different population group than the one under study is the potential for the two populations to vary in important ways that affect costs. For example, effective prenatal care for women at high risk of having LBW infants, who are most likely to be the targets of public programs, is likely to be more intensive and hence more expensive than routine prenatal care for women at low risk (Huntington and Connell, 1994). However, four of the six cost-benefit analyses of prenatal care presented in Table 1, most of which were targeted to low-income women, used general population estimates of the cost of routine prenatal care for estimating the incremental costs of

[1] "Gross-costing" estimation uses cost estimates for units of inputs and outputs that are large relative to the intervention being analyzed. For example, cost estimates for hospital stays or doctor visits would be used instead of the costs of the time and materials expended during these encounters. The latter method is referred to as "micro-costing" estimation (Gold et al., 1996).

increased early and adequate prenatal care (IOM, 1985; Morales et al., 1985; OTA, 1988; Gorsky and Colby, 1989). This has the effect of underestimating costs in these analyses.

3. Sensitivity Analysis

Sensitivity analysis was performed on one or more cost components or assumptions in four of the studies reviewed (IOM; 1985; OTA, 1988; Joyce et al., 1988; Long et al., 1994). All of these studies used synthetic techniques to produce estimates of, respectively, the net cost savings of extending prenatal care to all high-risk pregnant women on public assistance, the net cost savings associated with the prevention of LBW infants, the cost-effectiveness of various strategies to reduce LBW births and neonatal mortality, and the total national costs of perinatal care. High and low estimates of the percentage of women with a given effect or cost outcome, the average magnitude of the effect or cost, and the discount rates were variously used in the analyses.

C. Summary of Study Findings

As was mentioned earlier, three types of studies were reviewed: cost descriptions, cost-benefit analyses, and cost-effectiveness studies. This section summarizes and synthesizes the findings of these studies, considering first the cost descriptions and then the economic evaluations.

1. Cost Descriptions and Comparisons

In 1989, payments made directly by patients and third parties for maternity-related care and care for the outcomes of pregnancy from delivery through the infant's first year of life were substantial, accounting for about 7 percent of personal health care spending by the nonaged population in the United States (Long et al., 1994). Costs were even higher than payments because of the added cost in hospital bad debt and charity care for delivery-related services provided to uninsured low-income women. Total costs were estimated as $27.8 billion, or $6,850 per mother-infant pair (Long et al., 1994).

The cost of and payments for prenatal care varied by birth outcome and the availability of health care. Chollet and colleagues found that charges for maternity and infant care were higher for

births with poor outcomes at all stages of care—prenatal, at birth, and postnatal. In a large employer-based health plan, average maternal and infant costs for preterm infants were 2.8 times higher than maternal and infant care costs for full-term healthy infants; for births with other significant complications these costs ranged from 1.7 to 6.9 times those of full-term healthy infants (Chollet et al., 1996).

Focusing only on hospital charges for newborns during the delivery stay, Nesbitt et al. (1990) compared charges in relatively underserved rural areas to those with better access to obstetrical services. The costs of neonatal care were higher among women in rural communities with relatively few obstetrical providers (in proportion to the number of births) than in rural communities with greater numbers of physicians practicing obstetrics in proportion to the number of births. Women in relatively underserved communities were less likely to deliver in their local community hospitals, and had a greater proportion of complicated deliveries and higher rates of prematurity.

Expenditures on neonatal care have been shown to vary based on the mother's use of prenatal care. In their investigation of hospital records for 7,000 births in McLennan County, Texas, from June 1987 through July 1989, Henderson (1994) found that women who had no prenatal care were almost three times as likely to have a LBW infant than women who used some prenatal care and that the hospital-related costs for their infants averaged more than $1,000 more than the costs of infants whose mothers did receive prenatal care. Wilson et al. (1992) found that, among newborns requiring NICU care in South Dakota from 1983 through 1985, those whose mothers had had inadequate prenatal care had hospital charges 1.48 times those for infants whose mothers had adequate prenatal care. (The researchers defined "inadequate care" as no prenatal care, care in the last trimester only, or fewer than five prenatal visits in all.)

2. Cost-Benefit Analyses

Four studies reviewed estimated benefit-cost ratios of additional spending on prenatal care; their estimates range from $1.49 in benefit for every dollar spent to $7 in benefit per dollar spent (Table 1). This variation resulted from different comparison groups of women, different cost components, and different estimation techniques.The low of $1.49 in cost savings per additional

$1 spent on prenatal care was computed for a 1988 cohort of Medicaid recipients in Missouri; costs for maternal delivery and postpartum care and neonatal NICU and neonatal care through 60 days post birth among women with inadequate or no prenatal care was compared to costs for women with adequate prenatal care, defined as starting care in the first trimester with at least nine total visits (Schramm, 1992). The high of $7 in cost savings per additional $1 spent on prenatal care was computed for a cross-section of women delivering at the Orlando Regional Medical Center during 1983 and 1984; costs for NICU care among women with no prenatal care were compared to costs for NICU care among women with some prenatal care (Morales et al., 1985).

The two estimates between these extremes both used the same synthetic estimation techniques and the same cost estimates of prenatal care and costs averted from reduced LBW infants. The widely cited estimate of $3.38:$1 was computed by the IOM (1985) for all women ages 15 to 39 years in the United States who received public assistance and had less than 12 years of education in 1980. A $2.57:$1 cost savings was found by Gorsky and Colby (1989) using the same cost estimates and methods applied to New Hampshire residents delivering between 1981 and 1984. The lower ratio found in the latter study may reflect a greater range of levels of risk in a more heterogeneous study population.

A benefit-cost ratio within the range above can also be computed from the excess hospital charges Moore and colleagues (1986) found for 100 consecutive deliveries at the University of California San Diego Medical Center among women who received no prenatal care compared to 100 consecutive participants in a Comprehensive Perinatal Program (CPP). The hospital cost savings was $2,821 per no-care patient and the total CPP program costs were $600 per patient, yielding a benefit-cost ratio of $4.70:$1.

Table 1.
Cost-Benefit Analyses of Early Initiation of Prenatal Care

Citation	Subjects	Intervention	Comparator	Benefits Valued	Benefit/Cost Ratio
IOM, 1985	Pregnant women ages 15-39 on public assistance and with < 12 years of education in 1980	Hypothetical case where all women received care in 1st trimester	Prevailing rates of 1st trimester initiation of prenatal care	Costs averted from reduced LBW infants	$3.38 : $1.00
Morales et al., 1985	Women delivering at Orlando Regional Medical Center, 1983-84	Cases with some prenatal care	Cases with no prenatal care	Incremental NICU costs	$7.00 : $1.00
Moore et al., 1986	Women delivering at the University of California San Diego Medical Center	Cases who began prenatal care prior to 20 weeks gestation and participated in a Comprehensive Perinatal Program	Cases with no prenatal care	Incremental charges for maternal and neonate delivery-related hospital stays	$4.70 : $1.00
Gorsky and Colby, 1989	Women delivering in New Hampshire, 1981-84	Hypothetical case where all women received at least 9 prenatal care visits beginning in the 1st trimester	Prevailing rates of early initiation and completion of 9 visits	Costs averted from reduced LBW infants	$2.57 : $1.00
Schramm, 1992	Women delivering under Missouri Medicaid in 1988	Cases who received at least 9 prenatal care visits beginning in the 1st trimester	Cases who began prenatal care in 3rd trimester or had no prenatal care	Incremental maternal delivery and postpartum, neonatal NICU, and other neonatal care costs in first 60 days past birth	$1.49 : $1.00

Because the effectiveness of prenatal care, and hence the benefit-cost ratio, vary depending on the population targeted, the OTA researchers conducted an analysis to determine the reduction in incidence of LBW among infants that would be needed for an expansion of Medicaid prenatal care benefits to all poor pregnant women to pay for itself. Costs were measured as the sum of the private fee equivalent for the additional prenatal care visits among poor women that would result from the expanded Medicaid coverage. Benefits were measured as costs averted from LBW babies and were obtained from the literature and secondary data sources, as described above. They concluded that the expansion of Medicaid eligibility to all pregnant women in poverty would cause an additional 18.5 percent of these women to initiate prenatal care in the first trimester of

pregnancy. Nationally, the extra prenatal care was estimated to cost about $4 million per year. Expected short- and long-term savings in health care costs associated with the prevention of each LBW birth were so great (between $14,000 and $30,000) that prenatal care would need to have only marginal effects on birthweight to be justified on cost grounds alone.

3. Cost-Effectiveness Analysis

Finally, at least one study found prenatal care to be more cost-effective than other programs and services in improving U.S. birth outcomes in terms of infant lives saved and LBW births averted. Joyce et al. (1988) analyzed a variety of strategies including health inputs, such as neonatal intensive care, prenatal care, and abortion, and federally-funded initiatives, such as family planning clinics, community health centers, maternal and infant care projects, and the Special Supplemental Food Program for Women, Infants, and Children (WIC). The direct program costs of increasing use of the different programs and services by 1,000 participants were obtained from various sources in the literature. Measures of program effectiveness were obtained from estimated multivariate regression equations of infant mortality and LBW rates for large U.S. counties in which the variables representing the magnitude of the various programs were entered. Cost-effectiveness was measured per neonatal death averted and per LBW birth averted. The results from both measures were similar: early initiation of prenatal care was the most cost-effective means of reducing the neonatal mortality and low birthweight rates, followed by WIC. Neonatal intensive care, although the most effective means of reducing neonatal mortality rates, was one of the less cost-effective strategies.

D. Gaps in the Literature

The state of current knowledge regarding the costs and cost-effectiveness of early and adequate prenatal care use has several gaps. For example, Long and colleagues conducted a thorough recording of the direct medical care costs and sources of payments associated with prenatal, delivery and postnatal care in the United States in 1989, a baseline year for the analysis of Medicaid expansions (Long et al., 1994). This study has not been updated since to determine how the total costs and the distribution of the cost burden may have changed with the full

implementation of the expansion and the development of new technologies and strategies for managing maternity-related complications.

The literature does not currently contain a cost-benefit analysis of prenatal care from the societal perspective that includes the full spectrum of relevant cost components. Current studies include only visit costs for prenatal care, excluding the increasing number and sophistication of accompanying diagnostic tests. They also neglect the costs of outreach programs that would be necessary to attain the *Healthy People 2000* goal for increased early initiation of prenatal care. In addition, no cost study went beyond direct medical costs of inadequate prenatal care to estimate the indirect costs of foregone wages from avoidable maternity complications or from caring for children born with preventable developmental problems.

The literature also contains no cost analyses of care for pregnant women with specific conditions, such as chronic hypertension, that could greatly complicate pregnancy and have detrimental effects on birth outcomes. Studies should be conducted of the burden of illness and cost-effectiveness of different treatment strategies for such women who are in need of intensive prenatal care. This has become more important as the repeated use of high-cost diagnostic tests, such as ultrasonography, has become commonplace in the clinical management of high- and low-risk pregnancies alike.

III. Smoking Cessation During Pregnancy

When a pregnant woman smokes, nicotine passes to the fetus through her blood. Babies born to women who smoke can have levels of cotinine (a major metabolite of nicotine) in their urine that are nearly as high as those of active smokers (Kuhn et al., 1998). As time passes after birth and their nicotine levels fall, these babies show symptoms of nicotine deprivation. The pregnant smoker also passes along cyanide and carbon monoxide to her baby, both of which are harmful to the developing fetus; carbon monoxide reduces the ability of blood to carry oxygen and thereby depletes body tissues of oxygen. Nicotine also constricts the blood vessels bringing blood to the fetus, further limiting oxygen supply. In the fetus, this oxygen depletion is thought to account for the fact that babies born to smoking mothers are smaller, lighter, and have smaller head circumferences than babies born to nonsmoking mothers. Smoking during pregnancy may have

lasting, perhaps permanent, effects on the brain and mental function of the child after birth. Some studies have linked maternal smoking with difficulties in verbal and mathematical abilities and hyperactivity during childhood (Kuhn et al., 1998).

Infant brain development continues after birth. Exposure of babies and small children to secondary smoke should therefore be avoided. For example, some studies have suggested that maternal smoking increases the risk of sudden infant death syndrome (Kuhn et al., 1998). This could be due to damage that the baby suffered before birth, smoke in the environment after birth, or the combination of prenatal and postnatal exposure. Stoddard and Gray (1997) suggest that tobacco smoke exposure from maternal smoking can lead to significantly increased child health expenditures for respiratory illnesses among preschool-aged children.

In 1993, about 26 percent of women of child-bearing age smoked (Husten et al., 1996). Studies have shown that only 15 to 20 percent of these women quit on their own when they learn they are pregnant (Kleinman and Madans, 1985). Thus, more than 20 percent of women may smoke during pregnancy, resulting in significant adverse maternal and child health and high health care costs. The incidence of low birthweight (LBW) births among smokers is about twice that among nonsmokers. An estimated 21 to 39 percent of LBW births are attributable to smoking during pregnancy (Oster et al., 1988). The medical and other costs of caring for LBW infants at birth and throughout their lifetimes can be substantial.

Smoking cessation programs for pregnant women have been found to be a very efficacious strategy for reducing LBW births and infant mortality. Trials of smoking cessation interventions for pregnant smokers offering primarily education and support have produced cessation rates ranging from 9 to 27 percent (Li et al., 1993). Many of these trials also have documented an increase in birthweight resulting from smoking cessation.

Thus, the development and dissemination of effective prenatal smoking cessation programs is an important policy objective. Effective prenatal smoking cessation programs could be a successful strategy for both improving the health of mothers and children and containing costs. The medical

costs associated with LBW births should be of concern to maternal and child health agencies, private insurance carriers, health care providers, and managed care organizations.

Healthy People 2000 included several goals related to reducing smoking during pregnancy and the associated health and financial consequences. These are:

- Reduce cigarette smoking to a prevalence of no more than 10 percent among pregnant women;
- Increase smoking cessation during pregnancy so that at least 60 percent of women who are cigarette smokers at the time they become pregnant quit smoking early in pregnancy and maintain abstinence for the remainder of their pregnancy; and
- Increase smoking cessation during pregnancy so that at least 45 percent of women with less than a high school education who are cigarette smokers at the time they become pregnant quit smoking early in pregnancy and maintain abstinence for the remainder of their pregnancy.

A. Types of Cost Studies Reviewed

We conducted a search of MEDLINE and CDC's Smoking and Health database for cost studies addressing the above national goals for smoking cessation during pregnancy. We found four cost description studies that estimated the medical care costs attributable to smoking during pregnancy. The remaining seven studies presented costs related to smoking cessation programs targeted to pregnant women. The major design features of these studies are summarized in Table A-2.

1. Costs Attributable to Smoking

All of the cost description studies were narrowly focused, including only direct medical costs at the time of birth/delivery or other pregnancy outcome. Oster et al. (1988) addressed only the additional neonatal intensive care unit (NICU) costs resulting from LBW infants born to smoking mothers. Li et al. (1994) refined these cost estimates by recognizing that the percentage of LBW births attributable to maternal smoking is greater among births weighing 1,500-2,499 grams than among those weighing less than 1,500 grams. Because the clinical need, and hence the NICU costs, are greater for births below 1,500 grams than those weighing 1,500-2,499 grams, the

average cost per NICU admission among all LBW infants, as used by Oster and colleagues, overstate NICU costs related to maternal smoking. Li and colleagues computed the incremental hospital and physician costs of the initial hospitalization for specific birthweight categories.

The distribution over birthweight categories is not the only significant determinant of differences in direct medical expenditures at delivery for infants born to smoking and nonsmoking mothers. Adams et al. (1997) used national survey data and multivariate regression analysis of actual delivery-related medical expenditures in 1987 for a sample of smoking and nonsmoking women stratified by pregnancy outcome (miscarriage or stillbirth, uncomplicated birth, and complicated birth). Thus, they captured the effects of differences between smoking and non-smoking mothers beyond birthweight distributions while controlling for region of residence, age, race/ethnicity, income, marital status, education and insurance coverage. Unfortunately, the authors did not have information on birthweights and therefore could not investigate the independent contribution of different birthweights and other factors to the estimated cost differences among smokers and nonsmokers.

In another paper, Adams and Melvin (forthcoming) investigated the costs of specific maternal conditions related to smoking during pregnancy. These conditions include ectopic pregnancies, spontaneous abortions, placental complications (e.g., placenta previa and abruptio placentae), premature rupture of the membranes, and preeclampsia.

2 Smoking Cessation

Four types of studies were found that analyzed smoking cessation programs, including cost descriptions, cost-benefit analyses, cost-effectiveness analyses, and decision analyses. Li et al. (1992) estimated the health care costs associated with LBW that could be avoided from a nationwide dissemination of smoking cessation methods. The authors investigated potential costs averted from two different dissemination strategies: (1) full dissemination to both public and private maternity patients and (2) stepped dissemination to these patients over a 10-year period.

They did not consider the costs of the different programs and therefore did not subtract these costs from the estimated program benefits.

Three cost-benefit studies did estimate costs averted from LBW births resulting from smoking cessation during pregnancy net of program costs. Marks et al. (1990) used a hypothetical prenatal smoking cessation program that included 15 minutes of counseling, printed instructional material, and two follow-up phone calls. Ershoff et al. (1990) investigated the cost-benefit of a serialized cessation program targeted to pregnant women added to a two-page pamphlet on the hazards of cigarette smoking during pregnancy and a two-minute discussion with a health educator. Costs were derived from the experience of 323 pregnant, English-speaking smokers, who were members of a large health maintenance organization (HMO), presenting at one of five health centers in Southern California from July 1985 through June 1987. Windsor et al. (1993) compared incremental costs averted net of program costs for a three-pronged health education and support system: (1) standardized cessation skills and risk counseling session, including a seven-day cessation guide; (2) reminder letters and reinforcement during follow-up visits; and (3) social support in the form of a buddy letter, a buddy contact, and a buddy tip sheet. Study participants were 814 pregnant smokers presenting to one of four Birmingham, Alabama clinics from September 1987 to November 1989.

Windsor et al. (1988) presented a cost-effectiveness study of a three-armed randomized controlled trial. All 309 women were given standard clinic information and advice to quit. Women randomized to group 1, the baseline comparator, were given no additional smoking cessation treatment; women randomized to group 2 were given the American Lung Association's manual *Freedom from Smoking in 20 Days*; and women randomized to group 3 were given a targeted manual *A Pregnant Woman's Self-Help Guide to Quit Smoking*. Only direct, variable program costs were included in the analysis. Cost-effectiveness was measured per smoker who quit during pregnancy.

The two final studies developed decision-analytic models to determine the level at which program costs would just equal benefits measured in dollars. Shipp et al. (1992) constructed two decision

trees—one for infant outcomes (preterm; term LBW; neither) and one for maternal outcomes (abruptio, hemorrhage, previa; preeclampsia; neither)—to compare two strategies: (1) providing a formal smoking cessation program for pregnant women who smoke, and (2) not providing such a program. With these models, they then determined the amount of money a prenatal program could invest in smoking cessation and still "break even" economically. Break-even costs were measured per pregnant woman.

Hueston et al. (1994) reexamined the break-even costs for a prenatal smoking cessation program adjusting the estimated benefits of smoking cessation on infant outcomes as follows: (1) only women who present for care in the first trimester receive a risk reduction with smoking cessation, and (2) the risk reduction associated with smoking cessation remains slightly higher than that of women who never smoked. Hueston and colleagues used the same cost data as Shipp et al. (1988) but measured cost-effectiveness per program participant.

B. Review of Methodologies

Except for the Marks et al. (1990) study, the cost studies of smoking during pregnancy and smoking cessation programs took the perspective of the payer. Thus, they all had very short analytic horizons and included only direct medical care costs.

1. Types of Costs

None of the studies included the full array of relevant costs—not even the full array of relevant direct medical care costs. Many of the studies included only the incremental costs of LBW infants, neglecting the increased maternal costs; many considered only short-term costs of the delivery hospital stay; and none of the studies attempted to measure the costs of secondary smoking for mothers who resumed smoking shortly after the child's birth. Furthermore, none of the studies considered the costs of forgone productivity from mothers who must stay home to care for sick children. Because more mothers are returning to work after the birth of their infants, these costs

could be large. Finally, none of the studies take into account the utility of the added years of life saved as a result of smoking cessation.

These limitations serve to underestimate the magnitude of smoking-related costs and hence the benefits (costs averted) from smoking cessation during pregnancy. The extra effort required to collect information on these additional costs may not be warranted given the stated purposes of the studies. However, the broader definition of costs and benefits would help in supporting more intensive and costly smoking cessation program required to meet the *Healthy People 2000* goal.

The efficacy and effectiveness studies of smoking cessation programs currently show them to be only 9 to 27 percent effective in getting pregnant women to quit smoking during their first trimester, when smoking cessation has its largest impact on the unborn child. The *Healthy People 2000* goal is to have 60 percent of smoking women who become pregnant quit smoking early in their pregnancy and maintain abstinence for the remainder of their pregnancy. Recognizing the lower success rate of smoking cessation programs among less educated women, the *Healthy People 2000* goal is for 45 percent of pregnant women with less than a high school education who smoke to quit early and remain abstinent for the duration of their pregnancy. To get these success rates, more intensive and costly programs may need to be developed. To justify these programs, more inclusive cost estimates will be needed.

2. Valuation of Costs

Many of the studies used costs of LBW developed by the OTA and other published sources as estimates of costs averted from smoking cessation programs (Oster et al., 1988; Marks et al., 1990; Li et al., 1992; Windsor et al., 1995). However, these costs are based on data from the mid-1980s, and the technology for caring for LBW infants has changed dramatically since that time. Thus, the cost estimates were out of date by the time these studies were conducted.

Other studies used average hospital charges from a small number of short-term hospitals in a given area—Li et al. (1994) used data from 33 short-term hospitals in Maryland and 13 children's

hospitals; Shipp et al. (1992) and Hueston et al. (1994) used data from only two San Francisco Bay hospitals; and Ershoff et al. (1990) used charges from a computerized claims system in the single HMO that was part of the study. Although this valuation method may be valid for the specific setting and geographic area studied, the generalizability of the cost estimates to other areas of the country is questionable.

Furthermore, cost data are often subject to more variation than the outcomes data in a clinical trial and therefore require larger samples for stable estimates. For example, Ershoff et al. (1990) found large standard deviations in both the experimental and control groups. Therefore, to obtain a stable estimate of the costs averted from the intervention, instead of using the actual resource costs utilized by the experimental and controls, the authors averaged the costs of care for newborns in each of the three birth outcome categories (pre-term, intrauterine growth retardation, and other) over the entire study sample (including experimental and control subjects) and estimated the difference in expenditures between the two groups by the differences in the incidence of the different outcomes.

3. Sensitivity Analysis

Nearly all of the cost studies conducted a sensitivity analysis on one or more of the parameter estimates in the cost models to account for the uncertainty in the estimates. Parameters investigated include the smoking prevalence, the smoking quit rates from the various interventions, and the various average costs of medical services.

C. Summary of Study Findings

1. Costs Attributable to Smoking

Oster et al. (1988) estimated that maternal smoking during pregnancy was responsible for 35,816 LBW births in the U.S. in 1983, or about 14.5 percent of all LBW births. They also estimated that 14,977, or 6.6 percent, of all admissions to NICUs were a result of maternal smoking and that these admissions cost approximately $272 million, representing 8.5 percent of total national

expenditures on NICU services. Finally, they estimated that the average cost of neonatal care was $189 to $288 higher for infants born to smokers than for those born to nonsmokers.

Li et al. (1994) found that NICU costs per LBW birth due to smoking during pregnancy were 16 to 18 percent lower than the NICU costs per LBW birth due to other causes. Nevertheless, the authors estimated the extra economic burden of pregnant smokers compared to never-smoking mothers to be $238 to $482 in 1992. After adjusting for inflation, the results of the Oster (1988) study come to $327 to $499, a similar but slightly higher result.

When costs other than NICU costs are considered as well, the economic burden of smoking during pregnancy is even greater. Controlling for region of residence, age, race/ethnicity, income, marital status, education, and insurance coverage, Adams et al. (1997) found that, in 1987, expenditures for an uncomplicated birth was the same for smokers and nonsmokers ($3,805 in 1987 dollars). However, the estimated cost of a complicated birth was significantly higher for smokers than for nonsmokers ($10,894 versus $6,544; $p < 0.01$). Projecting these estimates to 1995, the authors found that smoking-attributable costs of complicated births were $1.4 billion (11 percent of costs for all complicated births) based on a smoking prevalence during pregnancy of 19 percent and $2.0 billion (15 percent of costs for all complicated births) based on smoking prevalence during pregnancy of 27 percent.

In their investigation of the smoking-attributable costs of selected maternal conditions, Adams and Melvin (forthcoming) pooled the odds ratios from published studies with data on total cases to estimate the number of cases attributable to smoking. They then multiplied the number of smoking-attributable cases by the average cost per episode for conditions ending without delivery or, for conditions ending in delivery, by the incremental cost over the costs of a normal delivery. These cost estimates were derived from a private insurance claims database. The authors found that smoking-attributable costs ranged from $1.3 million for premature rupture of the membrane to $86 million for ectopic pregnancy. Smoking during pregnancy apparently protects against preeclampsia and saves between $36 and $49 million, depending on the prevalence of smoking. Over all maternal conditions, smoking-attributable costs ranged from $135 to $167 million.

2. Costs of Targeted Smoking Cessation Programs

The studies described above show that smoking during pregnancy is a preventable cause of higher health care costs. Li et al. (1992) estimated that a minimum of 250,000 LBW births must be prevented during the 1990s to achieve the *Healthy People 2000* LBW objective of 5 percent of total births and that 12 to 18 percent of the objective might be accomplished by dissemination of tested smoking cessation methods. Thus, considering the OTA estimates of costs averted from fewer LBW births, the authors estimated that cost savings from the dissemination ranged from $22 million to $59 million in reduced health care costs for LBW infants alone.

The estimated benefit-cost ratios for smoking cessation programs for pregnant women reported in the literature varied widely, from a low of $2.80:$1 in Ershoff et al. (1990) to a high range of $17.93:$1 to $45.83:$1 in Windsor et al. (1993) (Table 2). Ershoff and colleagues had a lower success rate (6 percent fewer LBW births) and higher program costs ($11.75 per participant) compared to Windsor and colleagues (8 percent fewer LBW births and $4.50 per participant program costs). In addition, Ershoff et al. used only short-term costs of prevented LBW births whereas Windsor et al. use the OTA estimates of short- and long-term costs of prevented LBW births. In their cost-benefit analysis of a hypothetical smoking cessation program, Marks et al. (1990) find a benefit-cost ratio for short-term costs of $3.31:$1 considering only short-term NICU costs and using a 5 percent success rate; estimated program cost was $30 per participant. Including the OTA estimates of long-term costs of prevented LBW births increases the benefit-cost ratio to $6.57:$1.

Sensitivity analyses found that the estimates were the most sensitive to the cost of the smoking cessation program, the cessation rate among program participants, and the baseline risk of LBW (Marks et al., 1990). Windsor et al. (1988) showed that smoking cessation programs targeted to pregnant women can be more cost-effective than general smoking cessation program; the higher success rates of the targeted programs provide a fair margin with which to expand program efforts.

Table 2.
Cost-Benefit Analyses of Smoking Cessation Programs for Pregnant Women

Citation	Subjects	Intervention	Comparator	Benefits Valued	Benefit/Cost Ratio
Ershoff et al., 1990	Pregnant women enrolled in a large HMO who smoked when they began prenatal care at 1 of 5 health centers in southern California, 7/85-6/87	2-page pamphlet on hazard of cigarette smoking during pregnancy and 2-minute discussion with health educator, plus serialized cessation program oriented to pregnant women	2-page pamphlet on hazard of cigarette smoking during pregnancy and 2-minute discussion with health educator,	Neonatal hospital and professional service charges	$2.80 : $1.00
Marks et al., 1990	All pregnant women in the U.S. who smoke	Hypothetical program of 15 minutes of counseling, printed instructional material and 2 follow-up phone calls	Prevailing prenatal care practices	Incremental hospital costs at birth and excessive long-term impairments among LBW infants	$3.31 : $1.00 for short-term costs only $6.57 : $1:00 including long-term costs
Windson et al., 1993	Pregnant women who smoked when they presented for prenatal care at 1 of 4 Birmingham, AL clinics, 9/87-11/89	Health education and risk counseling during first prenatal visit, reinforcement during follow-up visits, and social support	Prevailing prenatal care practices	Incremental hospital costs at birth, rehospitalization in first year, and excessive long-term impairments among LBW infants	$17.93 : $1.00 to $45.83 : $1.00

Shipp et al. (1992) compared the costs and benefits of providing a formal smoking cessation program to pregnant women who smoke with those when no such formal program is provided to determine the level at which program costs would just equal benefits measured in dollars. The authors found that smoking cessation programs had a break-even cost of $32 per pregnant woman in the overall U.S. population of pregnant women. When the model was varied to fit specific U.S. subpopulations, the break-even costs varied from $10 to $237 per pregnant woman. The incidence of preterm LBW had the greatest impact on the cost.

Hueston et al. (1994) adjusted the model developed by Shipp et al. to apply the risk reduction from smoking cessation only to women who present for care in the first trimester. They found that smoking-cessation programs are cost-effective if the program costs $80 or less per person for a

general cross-section of U.S. women when the frequency of LBW is considered as the primary outcome. In general, the authors found that programs must decrease smoking rates by 2.15 percent to justify every $10 in program costs.

D. Gaps in the Literature

There are several gaps in the published studies of the costs attributable to smoking and economic evaluations of smoking cessation programs. None of the cost studies of prenatal smoking cessation programs investigated the distributional impact of implementing the programs. None identified population groups over which the benefits and costs may vary, nor did any of the studies discuss the share of the burden of smoking-attributable costs that are borne by patients and their families, insurers, employers, the health care system, and government agencies or how this distribution of costs would change with an effective smoking cessation program.

None of the economic evaluations investigated smoking cessation programs targeted to women with less than a high school education or other "hard-to-reach" populations of pregnant women. Effective smoking cessation programs may need to be more intensive and hence more expensive than programs designed for a more general population of pregnant women.

Finally, more comprehensive cost-of-illness and economic evaluations are required. These more comprehensive studies would include a broader array of both maternal and infant outcomes and their associated costs. For example, studies that model the long-term costs of maternal smoking, including the impact on outcomes and costs of mothers resuming smoking after delivery, are absent in the literature.

IV. Increasing Childhood Immunization

Immunizations have been demonstrated to be an effective means of preventing a number of childhood diseases. Although national immunization levels in the early 1990s showed that children were receiving their vaccinations by school or preschool enrollment, very young children were not receiving their vaccinations on time. In 1991, for example, nearly all (97-98 percent) of children in

the United States were up to date in their recommended childhood immunizations by school enrollment; however, up to 40 percent of two-year-old children had not received their immunizations at the recommended ages (Freed et al., 1993).

Immunization at school entry does not prevent the morbidity and mortality in infancy and early childhood that most of these vaccines were developed to eliminate. The failure to immunize at the younger ages was a primary cause of the severity of the 1988-1990 outbreak of measles in California. More than half of the hospital patients were younger than five years old, and the highest incidence of measles cases was among infants (< 12 months of age) (Dales et al., 1993).

The high immunization levels seen among school-aged children were achieved only through public health laws that require proof of immunizations before the students enroll. No similar law exists for younger children. Therefore, to combat the low compliance with childhood immunization schedules among very young children, the Childhood Immunization Initiative (CII) was implemented in 1993. CII is a national strategy to ensure high vaccination coverage of children during the first two years of life by building a comprehensive vaccination financing and delivery system. The national initiative focuses on five areas: (1) improving the quality and quantity of immunization services; (2) reducing vaccine costs for parents; (3) increasing community participation, education and partnerships; (4) improving systems for monitoring diseases and vaccinations; and (5) improving vaccines and vaccine use.

National immunization levels among children aged 19 to 35 months have improved markedly since the early 1990s. For the period July 1996 to June 1997, the reported coverage rate of 83 percent in this age group was the highest ever recorded, but this rate may be leveling off. To reach the *Healthy People 2000* goal of 90 percent coverage requires a fully functional, multidimensional vaccination delivery system (NCHS, 1998). Important components of this system are state- and community-based computerized vaccination registries, which include all children from birth and can identify children in need of vaccines and recall them for missed vaccinations; ongoing quality assurance and information feedback activities; continuous education programs for parents and

health-care providers, which remain to be fully created and implemented; and stronger, expanded links to the Special Supplemental Nutrition Program for Women, Infants, and Children.

A. Types of Studies Reviewed

We found many economic studies of the introduction and timing of new vaccines to the basic series of immunizations recommended for administration during childhood (e.g., Bloom et al, 1993; Lieu et al, 1995; Margolis et al, 1995). We also found references for many effectiveness studies of different interventions aimed at increasing the delivery of childhood immunizations. However, we found only three studies indexed as studies of the costs or cost-effectiveness of interventions to increase the delivery of immunizations.

One study investigated the costs of direct medical care and epidemic control activities resulting from the 1988-1990 outbreak of measles in California (Dales et al, 1993). The other two are cost-effectiveness studies. The first investigated the cost-effectiveness of a special one-day Children's Immunization Day in New York City compared to the costs of providing immunizations in clinics (Fairbrother and DuMont, 1995). The second study provides the plans for a cost-effectiveness study of the New Jersey Comprehensive Immunization Project's computerized immunization registry and tracking system (Pratt et al., 1997).

B. Review of Methodologies

Although only three studies were found, they demonstrate an interesting array of methodologies. Two of the three cost studies reviewed take a societal perspective, including direct costs of the intervention and indirect costs of illnesses prevented with the intervention studied (Dales et al., 1993; Pratt et al., 1997). The third study includes only the costs of the intervention (Fairbrother and DuMont, 1995).

All three studies used micro-costing techniques to value the resources consumed in implementing the intervention. They each began with a detailed catalog of the labor time and other resources

expended in planning and implementing the intervention and determined the actual costs of these resources. Gross costing techniques were used by Dales and colleagues to value the medical care consumed by persons with measles during the epidemic in California during 1988-1990.[2] The actual number of measles hospital admissions were counted but assumptions were made about the number of outpatient visits. Average costs from other secondary sources were multiplied by these counts to get estimates of total medical care costs. A similar methodology will be used by Pratt and colleagues to measure averted costs of childhood illnesses for cost-benefit studies of the New Jersey immunization registry.

Gross costing techniques introduce uncertainty into the cost estimates. The impact of this uncertainty can be measured with sensitivity analyses. Dales and colleagues did not conduct a sensitivity analysis on any of the parameter estimates in their study. Sensitivity analyses of several parameter estimates are planned for the New Jersey immunization registry (Pratt et al., 1997). These parameters include the time horizon for the registry technology, the discount rate, and overhead, medical and computer cost estimates.

C. Summary of Study Findings

The California measles epidemic of 1988-1990 was the worst in the state in more than a decade, with 16,400 reported cases, 3,390 hospital admissions, and 75 deaths. A disproportionate share of the cases was among infants and low-income Hispanic communities in southern and central California. Low immunization levels were blamed for the severity of the outbreak. Epidemic control activities included special outbreak control programs in schools and child care centers, colleges, detention facilities, and health care facilities in which efforts were made to identify and immunize all individuals who had not been immunized or who had been immunized at 12 to 14 months of age, when the vaccine is less effective than at 15 to 18 months of age. Community outbreak control programs included lowering the recommended age for receipt of the measles

[2] See footnote 3 for a description of 'gross-" and "micro-costing" estimation.

immunization, expansion of public immunization clinic services, and multilingual general publicity in the form of news releases, mailings, leaflets and posters placed at community gathering places.

The costs of medical care and outbreak control for the epidemic was estimated by Dales et al. (1993) at $30.9 million. This estimate is conservative as it does not include indirect costs such as lost income and productivity by working adults who became ill or who missed work to care for ill children, the 75 persons who died, or staff diverted from other activities in local health departments and medical care facilities to help in epidemic control.

These high costs suggest that preventive immunization of younger children may be cost-effective. However, the most cost-effective strategies for accomplishing the *Healthy People 2000* immunization objectives for young children have not been identified. The one completed cost-effectiveness study indicates that reaching unimmunized and/or underimmunized infants and toddlers to get them up to date in their vaccinations may be fairly expensive.

A Child Immunization Day (CID), similar to those used in developing countries, was planned and conducted in New York City in 1993. The CID had dual goals of increasing immunization coverage of children under 5 years, with special emphasis on children from birth to age 2, and linking children with health insurance and ongoing sources of primary care if needed. To collect information with which to estimate costs, Fairbrother and Dumont (1995) conducted a semi-structured interview of key members of the planning group and Steering Committee. They supplemented this information with an examination of financial records for the event from various agencies. The total estimated costs of the CID, including the costs of time spent by event planners and outreach coordinators, clinic expenses, a special hot line at the Department of Youth Services, publicity, refreshments and educational materials, and the vaccine costs, was $822,073, of which $95,043 was attributable to the vaccine costs alone (Fairbrother and Dumont, 1995). The single major element of cost was for event planners and outreach coordinators. The total cost per immunized children of the CID was $279, while it costs only $75 to $115 per visit to immunize a child at a health clinic (Fairbrother and Dumont, 1995). Thus, based on the single outcome of increased immunizations, the CID campaign was not cost-effective. However, whether the

campaign reached children who otherwise would not have been immunized is not known. In addition, no attempt was made to measure the success of or benefits from enrolling children in health insurance coverage or linking them up to a primary care provider.

One promising approach to increasing immunization coverage among small children involves immunization registry and tracking systems. Pratt et al. (1997) present their methodology for a planned study of the value generated from New Jersey's investment in a computerized immunization registry and comparison of the value of the registry intervention with other health care interventions. Personnel costs for administering increased immunizations will be obtained from time and motion studies. Micro-costing methods will also be used to determine other resource costs of administering increased immunizations; the costs of the registry, including costs of the computer software and hardware, installation, personnel to operate the system, maintenance, training and overhead; and costs of the increased quantity of vaccines. Other direct costs of treating an increased number of adverse side effects and indirect costs of treatment of vaccine-preventable diseases will be obtained from the literature and consultation with medical and administrative personnel. Net costs will be measured per child immunized, as well as per population served by the registry.

The proposed study will provide useful information about the economic viability of an immunization registry and will allow the state of New Jersey to measure the cost-effectiveness of its registry and its impact on increasing immunization rates in the state. Pratt and colleagues caution that assumptions that are necessary to complete their cost-effectiveness analysis will make the results generalizable only to communities with similar population demographics and average parental income. However, the methods used in the analysis will be generalizable to any immunization registry project.

D. Gaps in the Literature

Many different strategies have been developed to increase the immunization levels of infants and toddlers. Besides special immunization days and immunization registries, these strategies include

case management, parental and provider education programs, free vaccine programs, Medicaid expansions, and the State Child Health Insurance Programs. The very few cost studies found suggest that a considerable amount of work needs to be done in estimating the cost of these strategies.

In addition, once these costs have been estimated, comparative cost-effectiveness and cost-benefit analyses of alternative strategies should be conducted so that policymakers can better target the limited funds available for these initiatives. As part of these evaluations, the relative distributional impact of each of these strategies on the budgets of the different levels of government (federal, state and local) and on providers and families should also be investigated.

V. Conclusion

We searched for descriptive cost studies and economic evaluations of strategies designed to meet five *Healthy People 2000* objectives addressing maternal and child health. We looked only for studies in the published literature in which costs or cost-effectiveness were the main theme of the study, rather than a supplemental or side study. For two of the objectives, concerning adolescent smoking and sexual abstinence, respectively, we found no such studies. For a third objective, on strategies to increase childhood immunization levels, we found only two such studies and a description of a planned study. For the objectives on early initiation of prenatal care and smoking cessation during pregnancy, however, a significant number of studies were found (12 and 11, respectively).

Although our search was not comprehensive, our failure to find any studies for the two adolescent objectives and very few on the children's objective points out a general lack of economic analyses on the burning issues of adolescents and children. A concerted effort must be made to develop and assess policies and programs that will allow us to make significant strides in alleviating the public health problems facing adolescents and children that we are beginning to see for pregnant women and their infants.

For the most part, the studies we did find were narrowly focused. Nearly all addressed only the short-term health care costs faced by a single payer—typically the health insurer—or a single public program. Few even included all the relevant costs faced by these payers. Costs analyses of prenatal care programs, for example, focused primarily on either costs related to the infant or costs related to the mother, and only rarely both the mother and child. No consistent method was used to value the costs, and the cost estimates were frequently not generalizable to other settings.

The paucity of studies suggests that the economic costs and cost-effectiveness of various alternative public health strategies has been understudied. With greater attention to the relative cost-effectiveness of the different strategies, we may be able to increase the health impact of the maternal and child health budget. However, we must first improve the sophistication of our methodological skills. Several guides to the conduct of economic evaluations have recently been developed (Petitti, 1994; Haddix et al., 1996; Gold et al., 1996; Schwalberg et al., 1998). With repeated application of the methods in these guides to maternal and child health strategies, the sophistication of the methods will improve. We encourage maternal and child health practitioners to familiarize themselves with these procedures and to employ them where possible.

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Appendix A

Summaries of Reviewed Studies

Table A-1. Descriptive Cost Studies and Economic Evaluations of Prenatal Care Use

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Cost Descriptions									
Nesbitt et al., 1990	Cost description of problem	Poor access to prenatal care	NA	Payer	Duration of delivery stay	Direct medical costs: Hospital charges for newborns during delivery stay	Hospital discharge abstracts detailing hospital charges for newborns	Mean charges in high and low outflow areas, by all payers, Medicaid only, and non-Medicaid	Not done
Chollet et al., 1996	Cost description of problem	Poor birth outcomes in an employer-based health plan	NA	Payer	24 mos. from 9/89 to 8/91, and the cohort born 9/89-8/90 through 1 year from birth	Direct medical costs: Cost of prenatal, delivery, and postnatal inpatient and outpatient care for mothers and infants	Charges from claims data for a large employer population 9/89-8/90	Average cost per case by birth outcome (i.e., normal full-term, normal pre-term, full-term with problems, extremely pre-term and other pre-term with problems	Not done
Long et al., 1994	Cost description of intervention	Prevailing perinatal practices in the United States, 1989	NA	Payer	First prenatal care visit through 60 days after delivery for maternal care and through the first year of life for infant care	Direct medical costs: -Maternal prenatal and postdelivery services -Delivery services -Newborn care (delivery to discharge) -Infant care (initial hospital discharge to first birthday)	From various secondary data sources	Total national payments and costs; average payments and costs per delivery	Conducted on key assumptions (unspecified)

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Cost Description of the Outcome									
Wilson et al., 1992	Cost description of outcome	Women with adequate prenatal care whose infants hospital stay involved care in a NICU	Inadequate prenatal care, defined as no prenatal care, only last trimester care, or less than 5 prenatal care visits	Payer	Duration of delivery stay	Direct medical costs: NICU costs for infants	Matched birth certificate and hospital billing records for all births requiring NICU care in South Dakota hospitals between 1983 and 1985	Ratio of NICU charges for infants whose mothers received inadequate prenatal care to charges for infants whose mothers received adequate prenatal care	Not done
Henderson, 1994	Cost description of outcome	Prenatal care, defined as any type of medical care received by a prospective mother.	No prenatal care	Payer	Duration of delivery stay	Direct medical costs: Hospital costs for infants	Regression analysis of charges from hospital records for 7,000 births in McLennan Co., TX, June 1987 through July 1989	Cost savings, defined as the difference in hospital charges per birth between infants whose mothers received any prenatal care and infants whose mothers received no prenatal care	Not done

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Cost Benefit Analysis of Single Intervention									
Institute of Medicine (IOM), 1985	Cost benefit	Prenatal care starting in the first trimester to all pregnant women ages 15-39 years on public assistance and with less than 12 years education (as proxy for high risk pregnancies)	Status quo	Payer	First prenatal care visit through the child's first year of life	Cost of intervention: Costs of additional prenatal care Costs averted from reduced LBW births: -Initial hospitalization -Rehospitalization -Long-term morbidity costs during one year	Average costs from literature times number of women with intermediate or inadequate prenatal care Difference in average costs for normal and LBW infants from literature	Net cost savings; benefit-cost ratio; break even reduction in LBW	Conducted on percentage reduction in LBW births
Morales et al., 1985	Cost benefit	Some prenatal care among women delivering at the Orlando Regional Medical Center (ORMC) during 1983 and 1984	No prenatal care	Payer	First prenatal visit through discharge from delivery hospital stay	Costs of intervention: Cost of providing prenatal care Costs averted: Cost of NICU during delivery stay	Average prenatal costs from the Orange Co. Health Dept. Average NICU costs from ORMC, 1983/84	Net additional cost of failure to administer prenatal care to all delivering women; cost-benefit ratio	Not done

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Moore et al., 1986	Cost benefit	Comprehensive Perinatal Program (CPP) offering obstetric care, nutritional assessment and support, social services, and home outreach service. Provided by certified nurse midwives in a network of 10 outlying community clinics. Mothers must have begun prenatal care prior to 20 weeks gestation.	100 consecutive deliveries at University of California San Diego Medical Center among women who received no prenatal care	Payer	First prenatal care visit to discharge from delivery stay	Cost of intervention: Prenatal professional fees (routine visits, performance and interpretation of nonstress tests and sonography) and intrapartum and postpartum professional services by CPP staff. Costs averted: Differences in maternal and neonatal hospital charges for delivery stay.	A per patient charge for CPP services were reported by program staff Actual hospital charges were obtained from the hospital's billing unit.	Excess hospital charges per no-care patient	Not done

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Congress of the United States, Office of Technology Assessment (OTA), 1988	Cost-benefit	Expansion of Medicaid coverage to pregnant women living in families with incomes under the FPL	Status quo	Society	First prenatal visit of mother to the 35th birthday of the child.	Cost of intervention: -Incremental costs of early prenatal care Costs averted from fewer LBW births: -Additional initial hospitalization costs -Rehospitalization costs in first year of life -Long-term health care costs for early intervention, special education, and institutional or foster care	Fees from a 1986 physician survey. Gross costing of costs with probabilities and average costs from the literature	Net savings in health care costs associated with the prevention of each low birthweight birth and effectiveness level required to break-even.	Conducted on estimates of the initial hospitalization costs, the percentage of LBW infants requiring the different long-term health care services, and the discount rate
Gorsky and Colby, 1989	Cost benefit	Adequate prenatal care to all women in New Hampshire, defined as beginning care in the first trimester and receiving at least 9 visits	Status quo in New Hampshire 1981-1984	Payer	First prenatal care visit through child's first year of life	Cost of intervention: -Added prenatal care costs for women receiving intermediate and inadequate prenatal care Costs averted from fewer LBW births: -initial hospitalization costs -Rehospitalization costs during first year -Long-term morbidity costs	From IOM (1985) study	Benefit-cost ratio; net cost savings	Not done

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Schramm, 1992	Cost-benefit analysis	Adequate prenatal care, defined as starting care in the first trimester with at least 9 total visits.	Inadequate prenatal care, defined as starting care in the third trimester or no care	Payer	First prenatal visit through 60 days following birth	Cost of intervention: -Difference in prenatal care costs Costs averted: -Difference in maternal delivery and postpartum care -Difference in NICU and other neonatal care begun within 60 days of birth	Paid claims from the 1988 Missouri Medicaid files	Benefit-cost ratio; net total savings in the state	Not done

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Cost-Effectiveness of Alternative Strategies									
Joyce et al., 1988	Cost-effective-ness of alternative strategies	NICU, prenatal care, abortion; family planning clinics, community health centers, maternal infant care projects, and WIC	NA	Society	Time period over which services are provided	Cost of interventions: Costs of increasing program/service use by 1,000 participants	All values estimated from literature	Costs per neonatal death averted and costs per low birthweight infant averted	Conducted with high and low estimates of effectiveness

Table A-2. Descriptive Cost Studies and Economic Evaluations of Smoking Cessation During Pregnancy

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Cost Descriptions									
Oster et al., 1988	Cost description of problem	Neonatal intensive care at birth related to maternal smoking	NA	Payer	Duration of delivery stay	Direct medical costs: Incremental cost of NICU admission over routine nursery care by 3 LBW groups	From cost estimates for 1976-78 found in the literature	Total US expenditures on NICU care attributable to maternal smoking and average cost of NICU care among infants of smokers	Cost per NICU admission
Li et al., 1994	Cost description of problem	Neonatal intensive care at birth related to maternal smoking	NA	Payer	Duration of delivery stay	Direct medical costs: Incremental hospital and physician costs of initial hospitalization	Hospital charges alternately from 33 short-term hospitals in MD and 13 children's hospitals × probability of LBW by weight; physician costs 10-20% of hospital charges	Average cost per low birthweight infant; net incremental cost of LBW v. NBW infant	Costs by DRG and by birthweight obtained from different sources and percentage added for physician services
Adams et al., 1997	Cost description of problem	Incremental maternal and infant care at deliver/birth that can be attributed to smoking	NA	Payer	Duration of delivery stay	Direct medical costs: Incremental medical costs of a complicated birth	1987 National Medical Expenditure Survey data by pregnancy outcome	Total costs of complicated delivery attributable to smoking during pregnancy	Smoking prevalence

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Adams and Melvin, forthcoming	Cost description of problem	Pregnancy-related maternal conditions caused by smoking	NA	Payer	Varied by condition but was typically a 60-day window around a claim with the related diagnosis	Direct medical costs: -Average costs for inpatient and outpatient care of ectopic pregnancies and pregnancies ending in spontaneous abortion -Incremental costs of inpatient deliveries with placental complications, preterm PROM, and preeclampsia over costs for a normal delivery	Odds ratio and percentage of women who smoke from published studies; average payments per case from private insurance claims data for large employer plans	Average or incremental costs per condition and total smoking attributable costs	Conducted on the percentage of women who smoke,
Li et al., 1992	Cost description of outcomes	Stepped and full nationwide dissemination of smoking cessation methods to pregnant smokers	No dissemination	Payer	From birth to age 35 of child	Direct medical costs: Incremental hospital costs at birth, rehospitalization in first year, and excessive long-term impairments among LBW infants	Literature (see OTA 1988 in Table 1) adjusted for distribu-tion of birthweights of infants born to smokers	Total costs of LBW averted from a reduction from maternal smoking during pregnancy; and incremental costs from no dissemination	Discount rate, dissemination impact, and smoking rate

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Cost Benefit Analysis of Single Intervention									
Ershoff et al., 1990	Cost-benefit in RCT	2-page pamphlet on hazard of cigarette smoking during pregnancy and 2-minute discussion with health educator, plus serialized cessation program oriented to pregnant women	2-page pamphlet on hazard of cigarette smoking during pregnancy and 2-minute discussion with health educator	Health maintenance organization	First prenatal visit through delivery	Cost of intervention: Personnel time, practice overhead, self-help materials, and postage Costs averted: Neonatal hospital and professional services	Micro-costing Charges from computerized claims system of HMO	Net benefit (cost savings) and benefit-cost ratio	Not done. But a simulation with best parameter values was performed for a HMO with membership of 100,000.
Marks et al., 1990	Cost-effectiveness and cost-benefit	Model program of 15 min. of counseling, printed instructional material, and 2 follow-up phone calls	Status quo	Society	Mother's pregnancy through the lifetime of child (up to 35 years)	Cost of intervention: Staff time, materials, and practice overhead Costs averted: Incremental hospital costs at birth and excessive long-term impairments among LBW infants`	Micro-costing Literature (see OTA, 1988 in Table 1)	Costs per LBW birth prevented, per death prevented, and per life-year gained; net savings in NICU costs and prevented disability among surviving LBW infants; benefit-to-cost ratio	Smoking cessation rates, program costs, proportion of LBW infants requiring NICU care; average relative risk of LBW infant from smoking; baseline risk of LBW infant; and relative risk of perinatal death

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Windsor et al., 1993	Cost-benefit	Health education and risk counseling during first prenatal visit, reinforcement during follow-up visits, and social support	Status quo	Program or agency	Duration of pregnancy	Cost of intervention: Personnel time and materials Costs averted: Incremental hospital costs at birth, rehospitalization in first year, and excessive long-term impairments among LBW infants	Micro-costing Literature (see OTA, 1988 in Table 1)	Cost-benefit ratio and total net savings	Behavioral impact, smoking population attributable risk, intervention costs, excess health care costs, and discount rates

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Analytic Horizon	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Cost Evaluation of Different Strategies									
Windsor et al., 1988	Cost-effectiveness in RCT	(1) Standard clinic information, advice to quit, and general quit smoking manual (2) Standard clinic information, advice to quit, and targeted quit smoking manual for pregnant women	Standard clinic information and advice to quit	Program or agency and patient	Duration of pregnancy	Cost of intervention: Personnel time, self-help educational materials, and patient's time	Micro-costing	Costs per patient who quit during pregnancy	Program effectiveness, costs of personnel and material costs
Analysis of Break-even Costs									
Shipp et al., 1992	Decision analysis	Hypothetical prenatal care smoking cessation program	Status quo	Program, payer	First prenatal visit to delivery stay discharge	Costs averted: Maternal and newborn stay in hospital	Charges from 2 San Francisco Bay hospitals	Break-even costs per pregnant woman	All maternal and infant outcomes and hospital charges
Hueston et al., 1994	Decision analysis	Hypothetical prenatal care smoking cessation program	Status quo	Program, payer	First trimester to delivery stay discharge	Costs averted: Newborn stay in hospital	Charges from 2 San Francisco Bay hospitals	Break-even costs per program participant	Program effectiveness and spontaneous quit rates

Table A-3. Descriptive Cost Studies and Economic Evaluations of Strategies to Increase Childhood Immunization Levels

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Time Frame	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Dales et al., 1993	Cost description of problem/ intervention	Epidemic control program	NA	Society	1988-1990, the length of the epidemic	Costs of epidemic control activities: -Additional vaccines -Staffing for special clinics -Clinic expansion Costs of medical care: -Hospital admissions -Outpatient care	Micro-costing from state and federal government budgets Gross costing using average inpatient costs from a 1989 LA county survey and assuming one outpatient visit per case at $80 per visit	Total cost of the measles outbreak	Not done
Fairbrother & DuMont, 1995	Cost effectiveness	Childhood Immunization Day to promote citywide child immunizations	Visit at a child health clinic for immunization	Payer, program decision maker	3-1/2 months of planning to the event day	Cost of intervention: -Costs of planning for and staffing intervention -Costs of vaccine -Costs of supplies, publicity, hotline, refreshments, educational materials and overhead	Micro-costing with data collected from semi-structured interviews of planning group and Steering Committee members supplemented by financial records	Cost per immunized child	Not done

Citation	Study Type	Problem or Strategy Analyzed	Baseline Comparator	Perspective	Time Frame	Costs Included	Valuation Method	Summary Measure	Sensitivity Analysis
Pratt et al., 1997	Cost effectiveness	Electronic immunization registry in New Jersey	Preintervention immunization and costa data at eight sites including AFDC, WIC, private provider, and FQHC sites and other interventions designed to increase immunization coverage levels	Society; health care system	Not specified but to include preparation phase to long-term costs of illness	Direct costs: -Personnel and resource costs of administering increased immunizations -Costs of the registry (e.g., software, hardware, installation, operation, maintenance, training and overhead) -Costs of treating an increased number of adverse reactions -Costs of increased no. of vaccines Indirect costs: -Costs of treatment of preventable disease	Micro-costing from administrative records From estimates in the literature and consultation with medical and administrative personnel	Economic returns in dollars per child immunized and/or per population served by the registry	Planned for the time horizon for the registry technology, the discount rate, and overhead, medical and computer cost estimates

Appendix B

Literature Review Methodology

We used multiple search strategies to identify relevant journal articles and reports that presented results of economic studies on the goals listed above. These strategies included reviewing previously published annotated bibliographies, conducting keyword searches on electronic databases, and reviewing reference lists. We began by reviewing three bibliographies on economic studies of MCH programs and interventions: *Economics of Reproductive and Infant Health: An Annotated Bibliography From 1980 to 1993* (CDC, 1995)*; MCH Economic Evaluation: Selected Topical Bibliography* (MCHB, forthcoming)*;* and *MCH Economic Evaluation: Supplement Bibliography* (MCHB, forthcoming). We identified 12 potentially relevant citations from these bibliographies.

We supplemented these citations by conducting online searches for economic studies of the selected maternal and child health topics. MEDLINE, Sociological Abstracts, and the Economic Literature Index databases were used; citations were limited to the period 1990-1998, those written in English, and those published in an American journal. The terms economic evaluation, outcome description, cost description, cost-outcome description, efficacy evaluation, effectiveness evaluation, cost analysis, cost minimization, cost effectiveness, cost utility, and cost benefit were crossed with terms for the *Healthy People 2000* goals listed above. The number of unique citations identified by MCH topic are listed below:[3]

- prenatal care: 62
- immunization and child/infant: 66
- smoking cessation and pregnancy: 5
- smoking and adolescents/youth: 6
- abstinence and adolescents/youth: 0
- low birthweight: 24
- infant mortality: 5

[3] Duplicates of any prior run were removed before ordering citations. Therefore, it should not be interpreted that there are only five citations on economic studies of infant mortality; many studies relevant to infant mortality were listed under prenatal care.

To identify additional articles on smoking cessation, a search was conducted of relevant literature on a Centers for Disease Control and Prevention (CDC) website.[4] This CDC search site included American studies published in foreign journals. Keywords employed in this search included "smoking", "pregnancy," and "cost." We identified four additional potentially relevant citations through this source.

Additional potentially relevant citations were identified through a review of reference lists in articles that had been obtained and discussions with colleagues. In particular, we identified some seminal studies conducted prior to 1990 that we felt were particularly important to include in the review. Finally, a *Science Citation Index* search on a 1994 review of prenatal care programs by Huntington and Connell identified 12 additional recent cost studies on that topic. Four of these citations were determined to be potentially relevant.

We obtained about 80 journal articles and monographs for closer examination. These articles and monographs were read by both authors of this report. We first determined whether the article addressed the selected *Healthy People 2000* objective. Many studies were rejected for further consideration because, while they addressed important related questions, they did not directly address the selected objective. For example, many of the prenatal care studies compared the costs of an enhanced prenatal care program to standard prenatal care among women who had begun care during their first trimester. Because the objective we selected concerns increasing the percentage of pregnant women who receive prenatal care in the first trimester, we did not further review these articles. Similarly, we found many cost-effectiveness analyses addressing whether to add a vaccination (e.g., varicella) to the series of childhood immunizations recommended for all children and whether to provide specific vaccines to children in infancy or early adolescence (e.g., for hepatitis B). However, we decided to limit our review to analyses of strategies to increase compliance with the recommended immunization schedules as that is the focus of the *Healthy People 2000* goal.

[4] Website address is: http://www.cdc.gov/nccdphp/osh/search/index.htm

These restrictions significantly reduced the total number of articles for review. The final count of articles abstracted and reviewed by subject area are as follows:

- prenatal care: 12
- smoking cessation during pregnancy: 11
- childhood immunization: 3

We found no relevant economic analyses of smoking cessation aimed at adolescents or abstinence education programs for youth. Although many cost studies of the financial impact of tobacco use and the cost-effectiveness of smoking cessation strategies exist, we found none that were specifically targeted to youth. Several studies of the efficacy and effectiveness of smoking cessation strategies targeted to youth were found, and these studies may have incorporated a cost study. However, none of the published reports for these studies were indexed as a cost study in electronic databases. Acquisition and review of these studies to determine whether they included unindexed cost analyses were beyond the scope of this project.

For each of the 26 articles meeting our review criteria, we abstracted the following information:

- the problem or question addressed
- the audience
- the alternative strategies analyzed
- the perspective of the analysis
- the analytic horizon
- the analytic method used
- whether the analysis measured marginal or incremental costs and effects
- the types of costs included and the valuation methods used to estimate costs
- the types of outcome measures included and the valuation methods used to estimate outcomes
- the discount rate used, if any
- sources of and methods for handling uncertainty in the parameter estimates
- the methods used to aggregate and compare costs and outcomes
- whether and how distributional effects were analyzed.